

Quantum Computing with Electron Spins

Chao Liu,^a Paolo Messina,^a John Schlueter,^a Frank Fradin,^a Orlando Auciello,^a John Carlisle,^a

Tijana Rajh,^b Ruihua Cheng,^c and Vinayak Dravid^d

^a Materials Science Division, ANL; ^b Chemistry Division, ANL;

^c Indiana University-Purdue University, Indianapolis; ^d Northwestern University

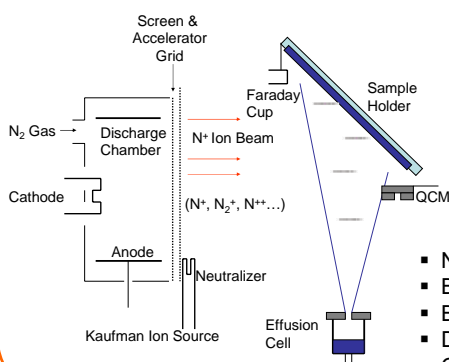
Motivation

Understand quantum spin phase coherence of endohedral N@C₆₀ molecules as potential qubits for quantum computing.

Major accomplishments

Prepare N@C₆₀ via low energy N⁺ ion irradiation of C₆₀ molecules adsorbed on a solid surface and purify a solution containing N@C₆₀ using High Performance Liquid Chromatography

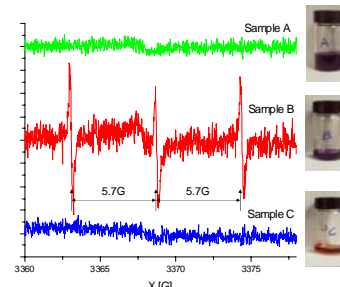
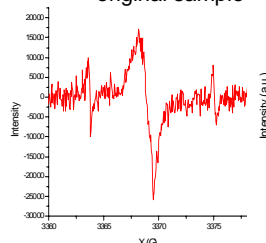
Producing N@C₆₀ molecules with ion-bombardment method:



Parameters

- N⁺ ion energy: 575 eV
- Beam current: 20 mA
- Beam cross-section: 3 cm
- Duration of irradiation: 10 min
- Chamber pressure: 4×10⁻⁴ Torr

EPR spectrum of original sample



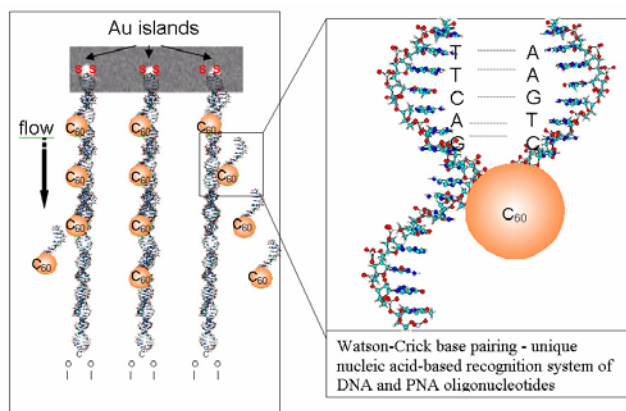
Sample B contains enriched N@C₆₀, while samples A and C contain fullerene impurities. The ¹⁴N triplet signal is observed only in sample B: The impurity signal has been removed.

Future Work

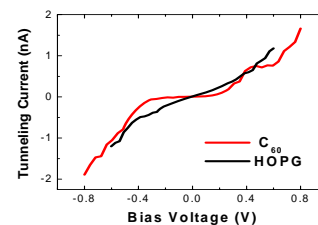
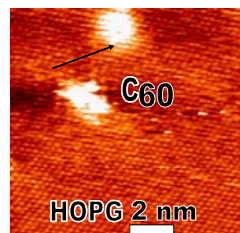
Development of DNA scaffolds for N@C₆₀ and single spin detection

DNA scaffolds for N@C₆₀

N@C₆₀ will be functionalized with carboxylate groups and anchored to polynucleoamide (PNA). N@C₆₀/PNA form a particle/adaptor complex that will attach to specific sites along double stranded DNA by molecular recognition

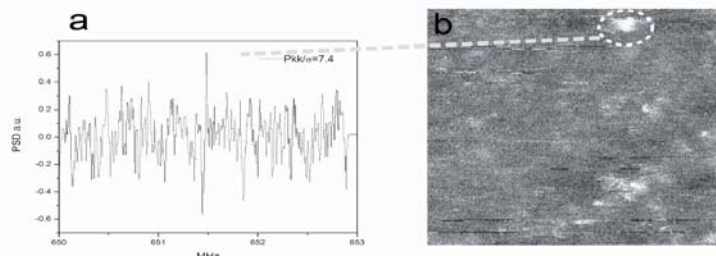


Single Electron Transistor (SET)-Scanning Tunneling Microscopy



Coulomb blockade effect in C₆₀

Electron Spin Resonance-Scanning Tunneling Microscopy (ESR-STM)



a) ESR-STM spectra of a single DPPH molecule detected via phase sensitive detection. b) STM image (10 × 10 nm²) of several DPPH molecules on Au(111).

➤ Qubit positions will be controllable to 3.5Å, the thickness of a single base pair

➤ We plan to use ESR-STM as well as radio frequency-SET to study the quantum spin phase coherence of N@C₆₀